An Introduction to Stop Analysis

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An Introduction to Stop Analysis

- What is STOP ?
- Creation of a thermal NASTRAN model
- Application of thermal model temperatures
- Predicting optics motions & deformed shapes
- Results processing options

What Is STOP ?

- Structural-Thermal-OPtical
  - Predicts optical performance of a system degraded by thermal deformations
- Three distinct Analyses: thermal, structural, & optical
  - Thermal analyst selects a few cases
    - Coldest or Hottest may not be worst optically, GRADIENTS!
    - Process is slow so the number of cases is limited
  - NASTRAN used to predict motion and deformation of optical components
  - Optical analyst applies these changes to the optical model or develops a sensitivity matrix for the system

Creation of a Thermal NASTRAN Model

- Created from a validated NASTRAN model
  - The Unit Temperature Change check is very important
  - Watch offsets, RBE's (effectively isolators)
- Use NASTRAN Thermal Analyzer (NTA) to Generate Temps for All GRIDs
  - Change Executive Deck for NTA
    - APP HEAT, SOL 1
    - GRIDS now only have one DOF (temperature)
  - Change all material cards to MATT4 or MATT5
    - Both contain only conductivity information
    - MATT5 makes the conductivity temperature-dependent

Creation of a Thermal NASTRAN Model
(Continued)

- Remove all SPC cards
- Replace all MPCs, including RBEx elements
  - RBE2 cards replaced with CELAS2 elements
    - The spring constant becomes the conductivity
    - Appropriate value may not be readily known
      - Only relative value is important
      - Use seed temperatures near both sides to minimize importance
  - RBE3 cards are removed
    - Use thermal model temperature for important lumped masses
    - Add CELAS2 from other geometry for less important ones
  - MPCs acting as a boundary condition are removed

Application of Thermal Model Temperatures

- Create initial thermal-NASTRAN grid map
  - Usually performed by visual estimation
  - Thermal nodes may be discarded or used many times
    - "Seed" around the perimeter of isothermal plates, at ends of bars
    - Typically ignore gradients through plates (use average)
  - Assign thermal model temperatures with SPC & TEMP cards
    - DOF is 1 for SPC
    - "Displacement" value is the temperature from thermal model
    - Apply to DOF 1 for GRIDS 1-NGRID
    - TEMP cards assigned to same GRIDs
  - Add a TEMPD card
    - lowest thermal model temperature
    - Provides starting points for temperature interpolation

Application of Thermal Model Temperatures
(Continued)

- SPC and TEMP cards must be called in the Executive
- Execute the NTA run for each thermal case
  - Request TEMP(PUNCH)=ALL
  - Output is a TEMP card for each NASTRAN GRID
  - Visualize these temperatures in P3, FEMAP, etc.
  - Thermal engineers should look at the results
    - Be able to explain hot and cold spots
    - Make sure all heaters are “working”
- Correct errors, add more seeds, and repeat NTA runs
  - Make same mapping changes to all runs
  - Add seeds in inappropriate cold or hot spots

Predicting Deformed Shapes

- Finished with NTA when all cases “look right”
- Update the original structural model
  - Add NTA output TEMP cards
  - Lock all 6 DOF on bolted interfaces
  - Create TEMPPx for through-plate gradients
    - Crucial for mirrors where you want to study deformations
    - Must be done by hand
- Run SOL 1 with NTA temperatures as the applied load
  - Look for unexpected stresses
  - Recover motions and deformations of all optics
    - Add thin plate over solids to recover rotations
    - Many will be point masses, encourage thermal model to include them

Results Processing Options

- Determine correct optical parameters to optimize
- Two ways to compute performance
  - Sensitivity matrix
    - Provided to structural analyst by optical analyst
    - For each optic change all 6 DOF, curvature, refraction index
    - Report effect on parameter of interest in spreadsheet
    - Mechanical analyst applies observed motions to this spreadsheet and calculates final value of parameter
    - Assume linearity, best for pointing error estimation
  - Ray-tracing
    - Optical Analyst modifies prescription to disturbed shape
    - Change curvature, index of refraction
    - Can study surface figure error via Zernike polynomials

Summary

- Successful STOP requires commitment from all three disciplines
- NASTRAN model does not have to be incredibly detailed but must be validated
- Automation of steps via scripts, macros increases the number of cases studied
- STOP can improve structural and thermal designs if done early enough